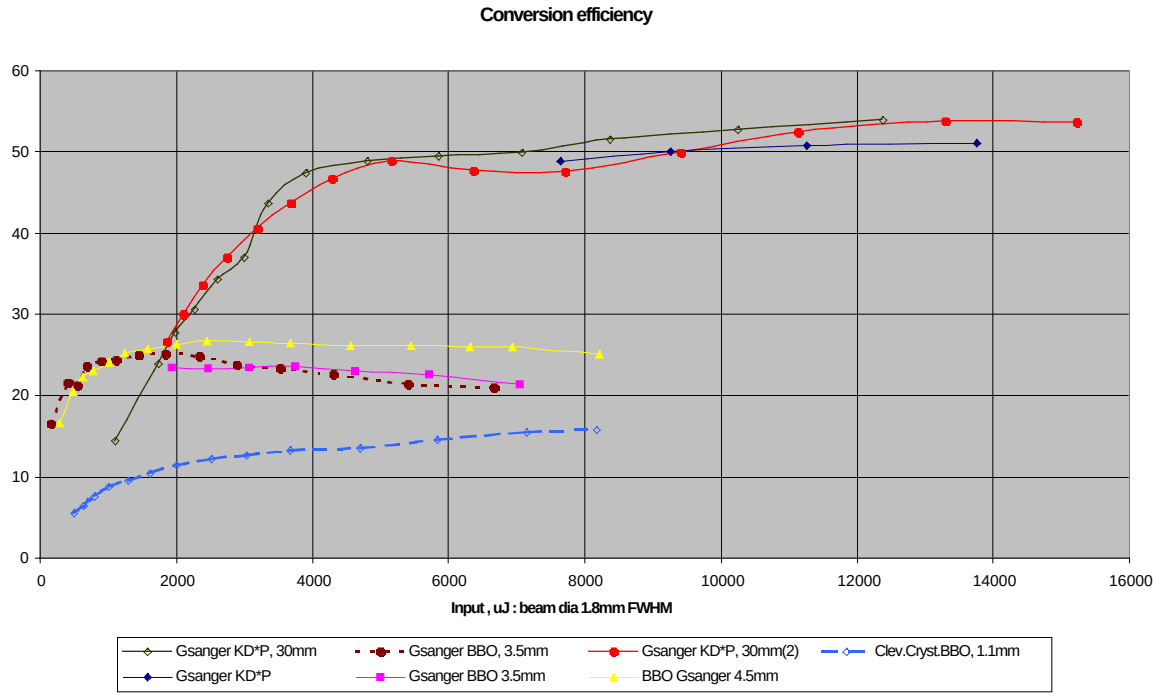
Report of the meeting for CLIC Photo-injector Study 28th June 2001

CTF3 Tech. Note 2001-029
Laser

Profiting from the brief passage of Ian Ross (RAL), an informal meeting was arranged to present the status of work on the Photo-injector studies for CTF3/CLIC.

The meeting was opened by S.Hutchins, who presented an overview of the system, with special attention to the list of subjects that had been identified for investigation in order to produce a design report for the system. The work was split between CERN, RAL and Strathclyde University; all of the tasks would be undertaken during the study period, finishing in the summer of 2002. The following are the main points of the discussions that took place.

Four main issues are being undertaken at CERN: Harmonic conversion efficiency, UV/Visible pulse manipulation, Optical measurements and Feedback stabilisation of the diode drivers. Initial tests using the CTF2 laser have shown that the assumed 5% efficiency of conversion and transport was pessimistic:



The IR-Green conversion is possible with >50% efficiency and the Green-UV conversion with >25%, the transport losses were assumed to be 66%, where 50% would be reasonable for a short, simple path to the cathode. This results in an overall efficiency estimate of about 8%, so the diode-pumping requirement could be reduced by 60%. This work is continuing, as further improvements are expected with the “flat top” distribution that will be used in the diode amplifiers, also other materials will be evaluated as the limitation of conversion efficiency to the UV is thought to be due to photon-induced absorption in the BBO material.

The aim of the UV/Visible pulse manipulation will be to demonstrate that the odd-even RF bucket switching, which is essential in the CLIC scheme, can be reliably done using the simple Pockels cell system that has been assumed. There are known reliability (ageing) problems with Pockels cells operated in CW

mode, and UV induced absorption was found to be a major problem during earlier work with an optical "feed-forwards" stabilising system. The PS-PO group is producing a suitable Pockels cell driver for this application, as it is not a commercial device. It is planned to start HV testing before the end of 2001.

The response time of a saturated amplifier to changes in the diode pump level is between 1-2 microseconds, and it is envisaged to use this in a feedback loop to maintain constant output from the RF gun. This requires a power supply and detectors with both high bandwidth and accuracy in order to meet the 3/00 stability that is specified. The power supply is being studied by the PS-PO group, it is hoped to test a prototype before the end of 2001. The penultimate amplifier in the chain is the most suitable for feedback control, as it will operate at a higher gain and double pass configuration it will have a greater dynamic range, the final amplifier will operate with a lower gain in a single-pass configuration. The input signal to the power supply will come from optical and electron beam measurements. The fast response time, high resolution and long pulse train (which implies high power) are a conflicting set of requirements which could be met by using Silicon Carbide or Diamond as the optical detector material, these will be evaluated this year.

During the discussions on the feedback system, it was realised that the CTF3 system must have a response time of 150ns, the filling time of the shorter CTF3 RF sections. This is beyond what can be achieved with power supply feedback, so a Pockels cell feedback system will be needed, this will add some extra loss in the system, and so some margin of amplifier power should be included. This item will be a CERN responsibility.

Ian Ross presented the status of work at RAL, where initial tests have started at 3kW diode pump power. The test amplifier section will be equipped with 5 x 1kW pump diode modules, which will enable higher gains to be achieved, but it has already demonstrated the predicted gain saturation. The programme of work on the amplifier will cover: amplifier gain control, pumping efficiency, fracture limit of Nd:YLF and thermally induced distortion.

The remaining optical studies are under way at Strathclyde Institute of Photonics, where E.Bente is investigating the possibilities of a high power oscillator for CLIC at 498MHz. The main difficulties to overcome are the synchronisation during the pulse train as the Oscillator will be Q-CW, only powered up for 200uS bursts to reduce the heat load, this increases the difficulty of achieving stable mode-locked performance. When the power pulse is applied relaxation oscillations are produced, an acousto-optic modulator is included in the cavity to control these and allow stable conditions to be quickly established.

H.Trautner reported the results of the "millicoulomb" test of photocathodes. Using a rented flashlamp-pumped, Q-switched UV laser from Quantronix, which can generate 200ns pulses, a series of cathodes were tested in the laboratory DC gun. The results showed that the 1.5% QE assumed for CTF3 appears to be the "natural" long-term QE of Cs_2Te cathodes, and that the CTF3 operating level is possible. Further testing will be needed to confirm the CLIC level of operation.

As all investigations and developments should be finished by August 2002, the possibility of testing the different elements as an integrated system is being investigated. E.Bente is investigating the possibilities of a high power oscillator for CTF3 at 1.5GHz, or a sub-multiple on the 3 GHz RF frequency. The Probe Beam line in CTF2 will be available October-November 2002, providing an RF gun capable of generating a 1.5us train of pulses, which is the RF pulse length from the modulator LIPS. Although the RAL test amplifier is only a short section, it is equivalent to $1/10^{th}$ of the power needed in CTF3, so that a total charge of >150uC could be produced in a pulse train if the input level to the final amplifier could be adapted, perhaps using flashlamp driven units for the low-level amplification. Ian Ross and Steve Hutchins will estimate the tests and evaluate the needs in space, power, cooling etc. and the possible intensities and repetition rates of the pulse trains that could be produced. It is proposed that a meeting be held at CERN at the end of September 2001, where the planned tests can be presented.

Reported by S.Hutchins